Refinement of MSX Attitude Using Infrared Astrometric Catalogs

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MSX Celestial Group

- Stephan Price (AFRL) : PI
- Michael Egan (AFRL) : Source extraction
- Image Construction
  - Sean Carey (BC): Positional refinement
  - Thomas Kuchar (BC) : Artifact mitigation
  - Don Mizuno (BC) : Dark offset corrections

Introduction

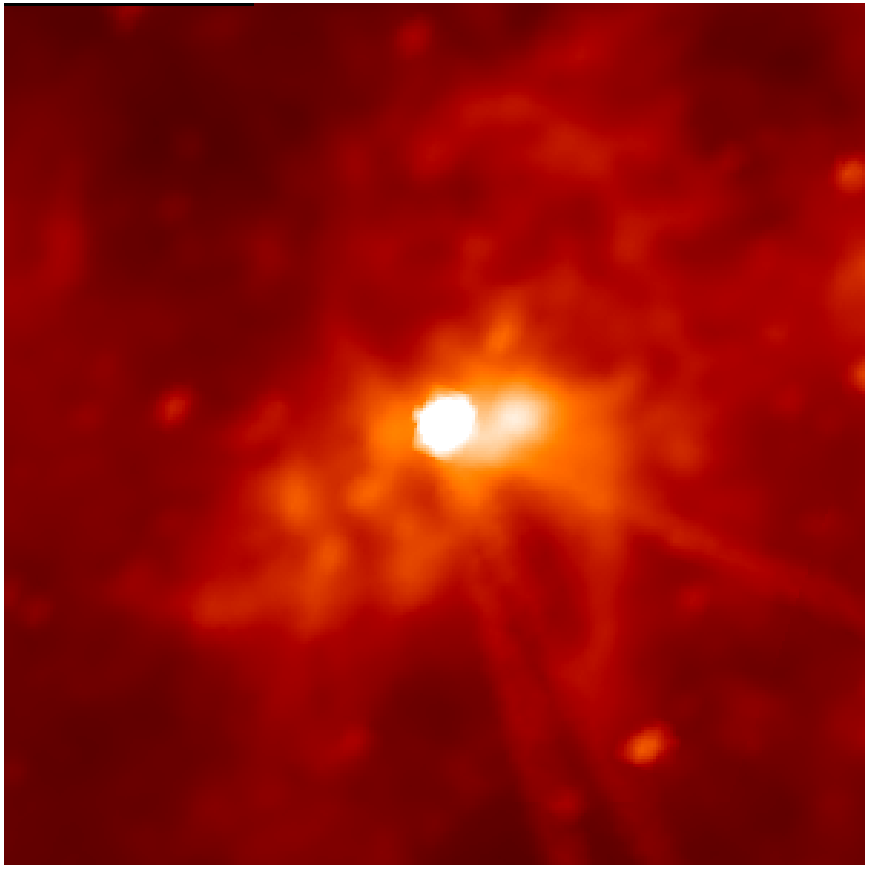
- Statement of Problem
- Description of DAF Errors & Artifacts
- Solution
- Fits to Astrometric Truth
- Summary

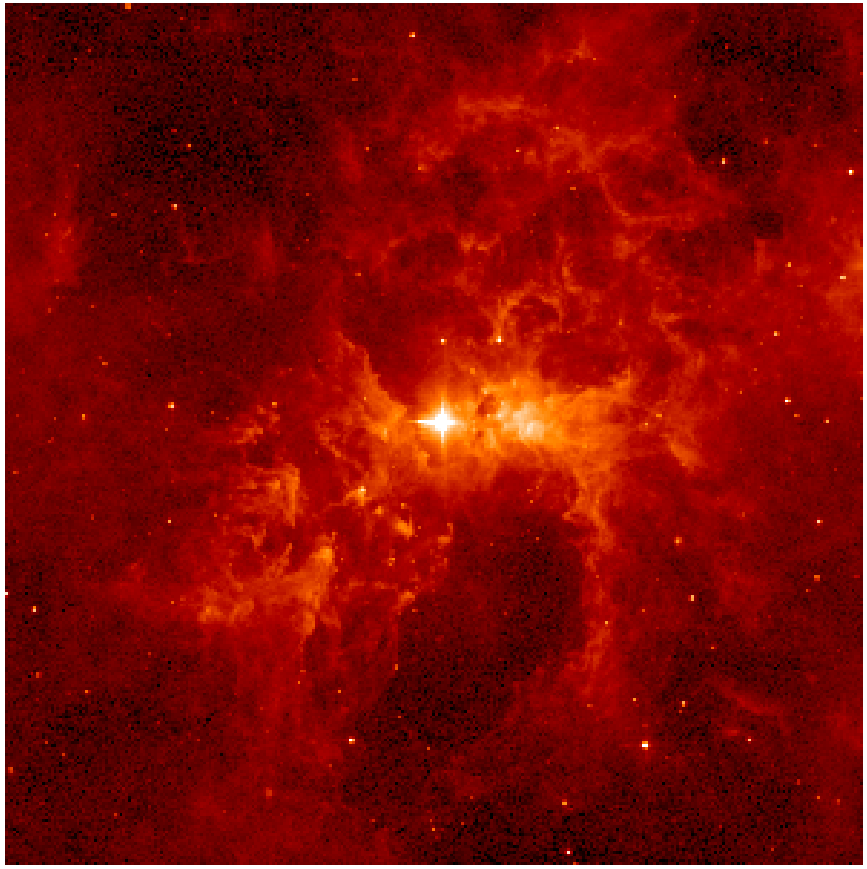
Statement of Problem

- Program Requirements
  - Tenth of detector (1.8″) Accuracy
  - Absolute Pointing
  - Needed for Image Registration, Super-resolution
- Astrometry
  - Ring Laser Gyros and Star Tracker
  - APL Definitive Attitude File (DAF)
    - time evolution of the boresight pointing
    - typical errors 15-45″, time varying

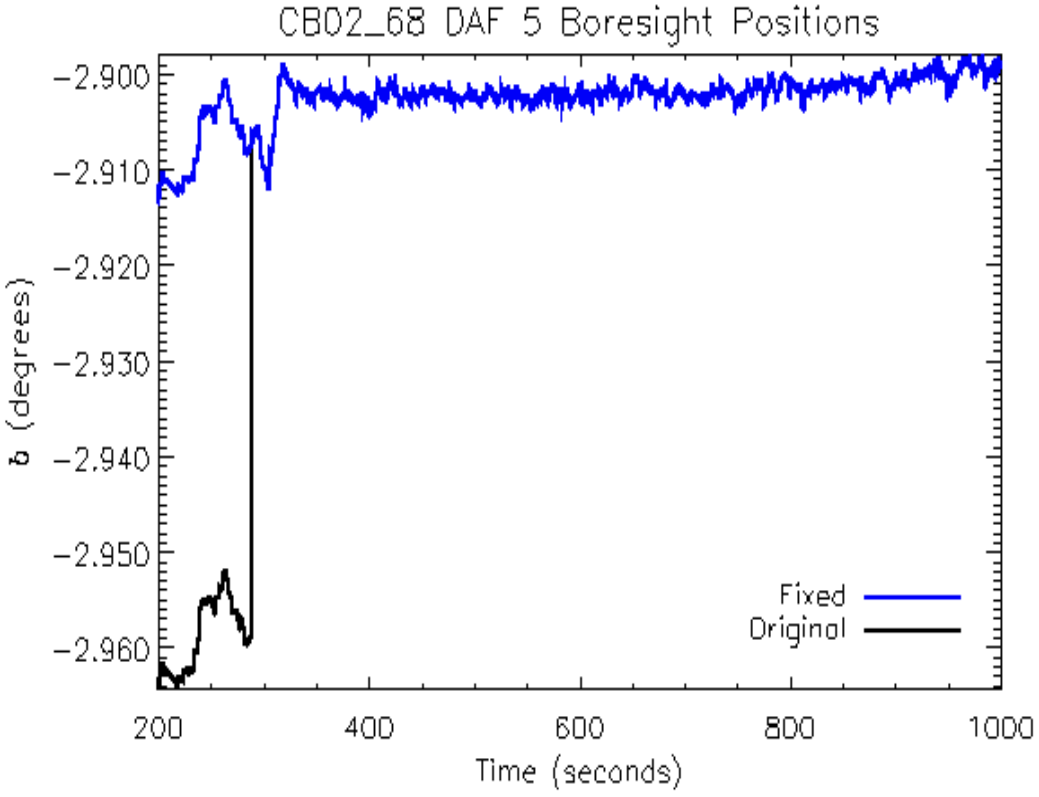
MSX/IRAS Comparison

Carina Nebula



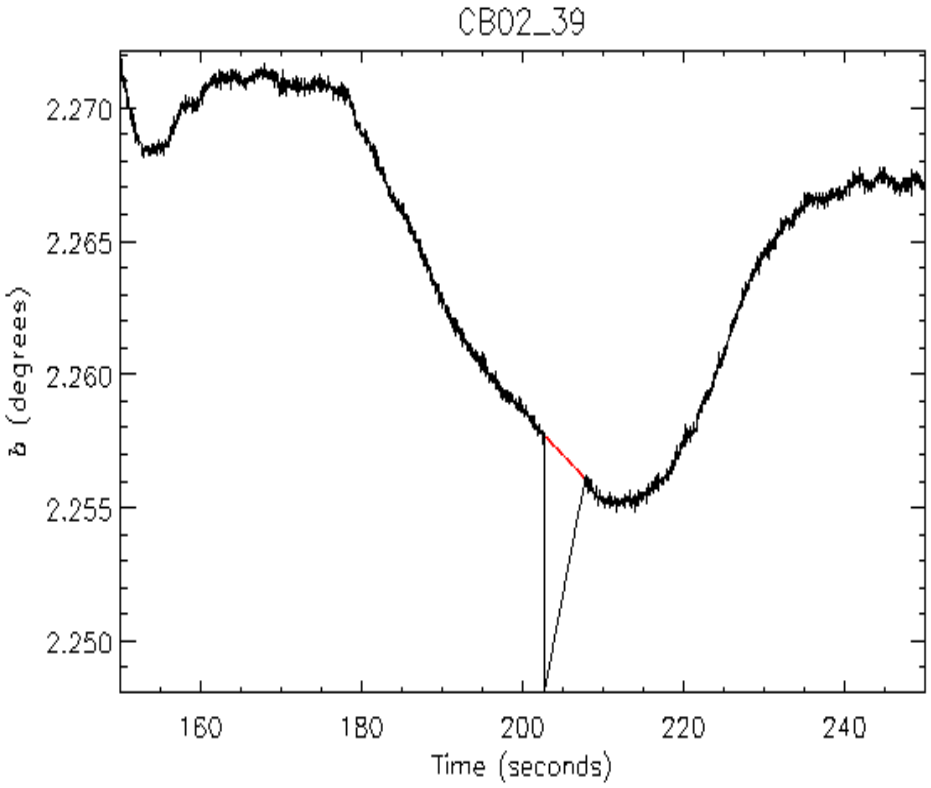


Description of DAF Errors
Jumps



- Jumps in Star Tracker
  - ~3% of long scans
- Register Bad Portion
  - Usually short segment
  - Use astrometric matches
- Update DAF
  - Adjust boresight
  - Difference quaternions
    - Create
    - Apply

Description of DAF Errors Gaps

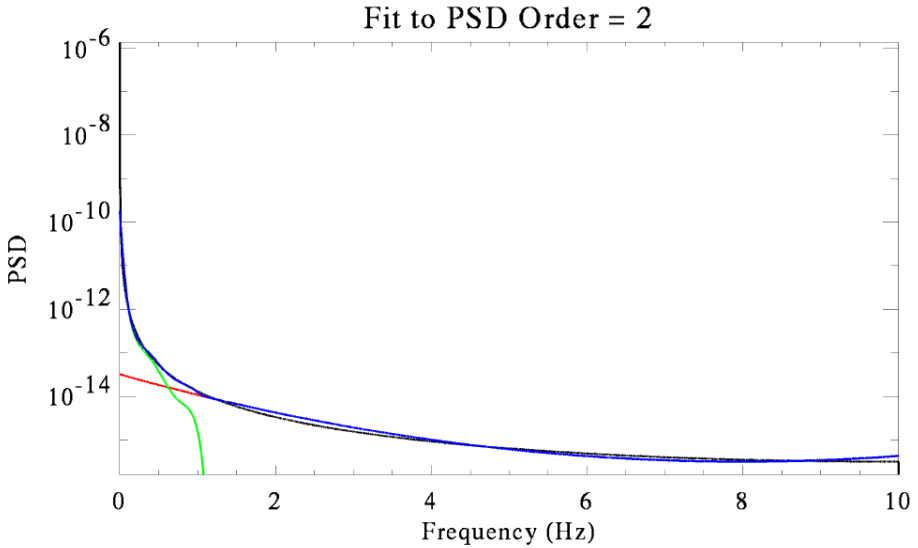


- Data Dropouts
  - ~3% of DCEs
  - Recover radiometer data
- Interpolate
  - Boresight position
  - Spacecraft position
  - Spacecraft velocity

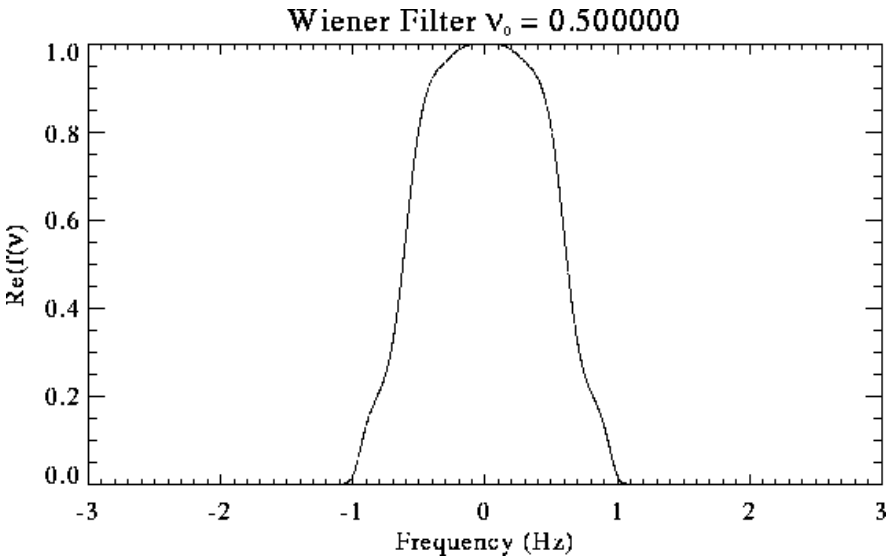
Description of DAF Errors

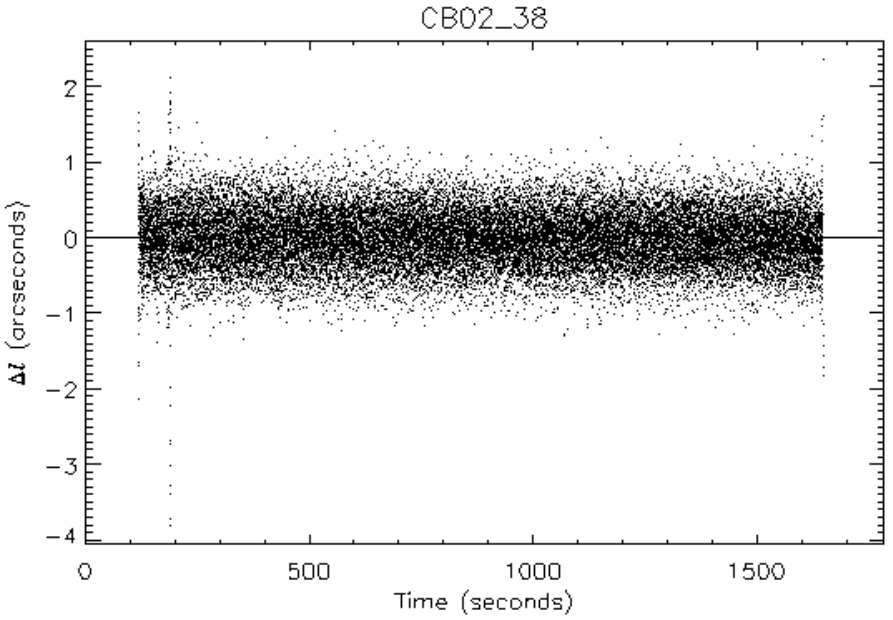
Noise

- High Frequency Noise
  - Amplitude up to 4″
  - 1/f noise for f > 1 Hz
- Wiener (optimal) Filter
  - Remove in-scan trend
  - Fit noise model to PSD
- Filter Boresight
  - In-scan
  - Cross-scan



Description of DAF Errors Filter Construction / Application





- In-scan boresight filter
- Cross-scan similar

- 1-4″ amplitude
- High noise segments

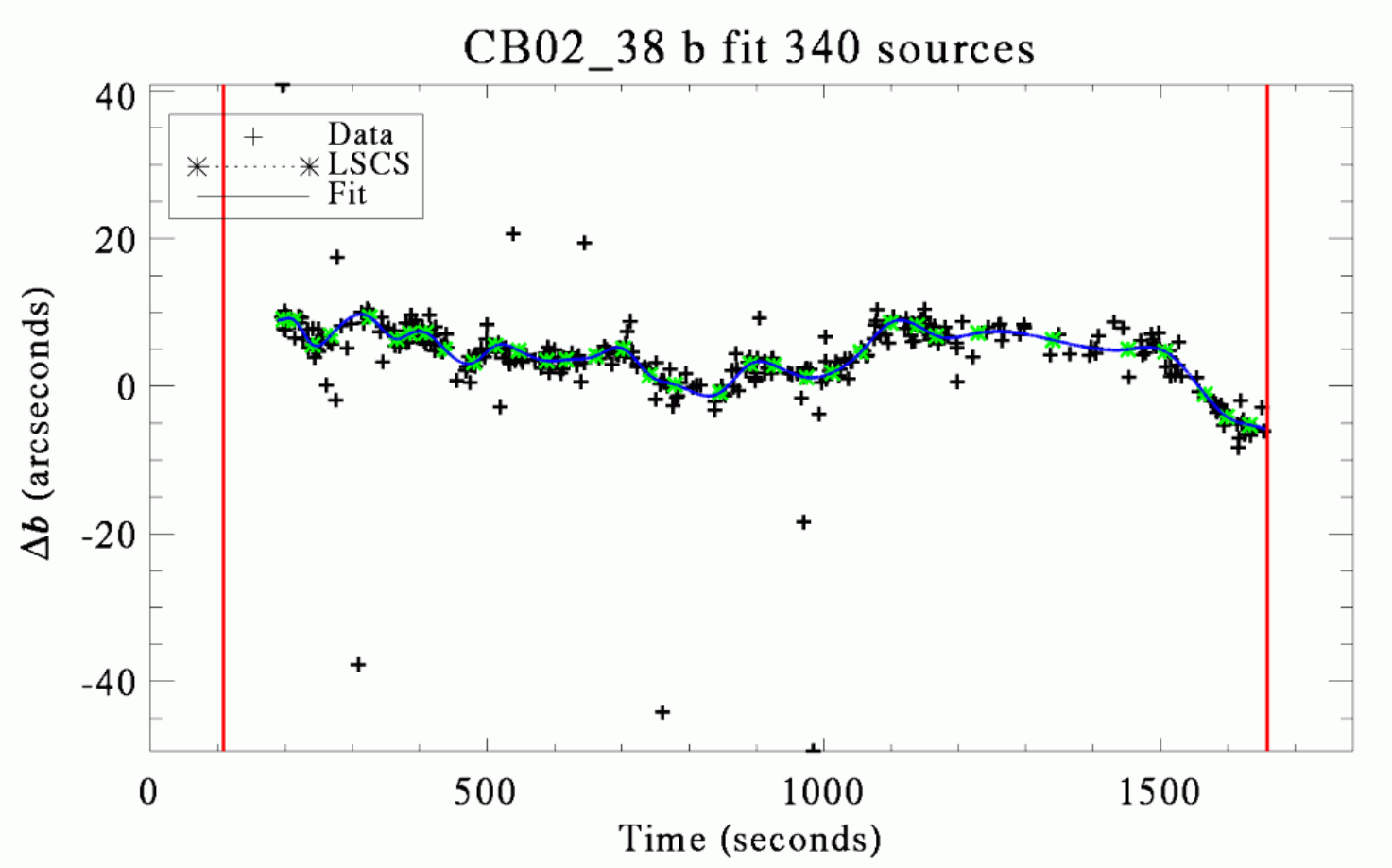
Description of DAF Errors Attitude Adjustment

- Point Source Association Criteria
  - Position Match
  - Simultaneous Flux Match
- Two step Fitting Process
  - Fit to Astrometric Truth
  - MSX to MSX Registration (Global Refinement)
    - Iterate until convergence (2 iterations)
- Cubic Splines
  - Least Squares Fit

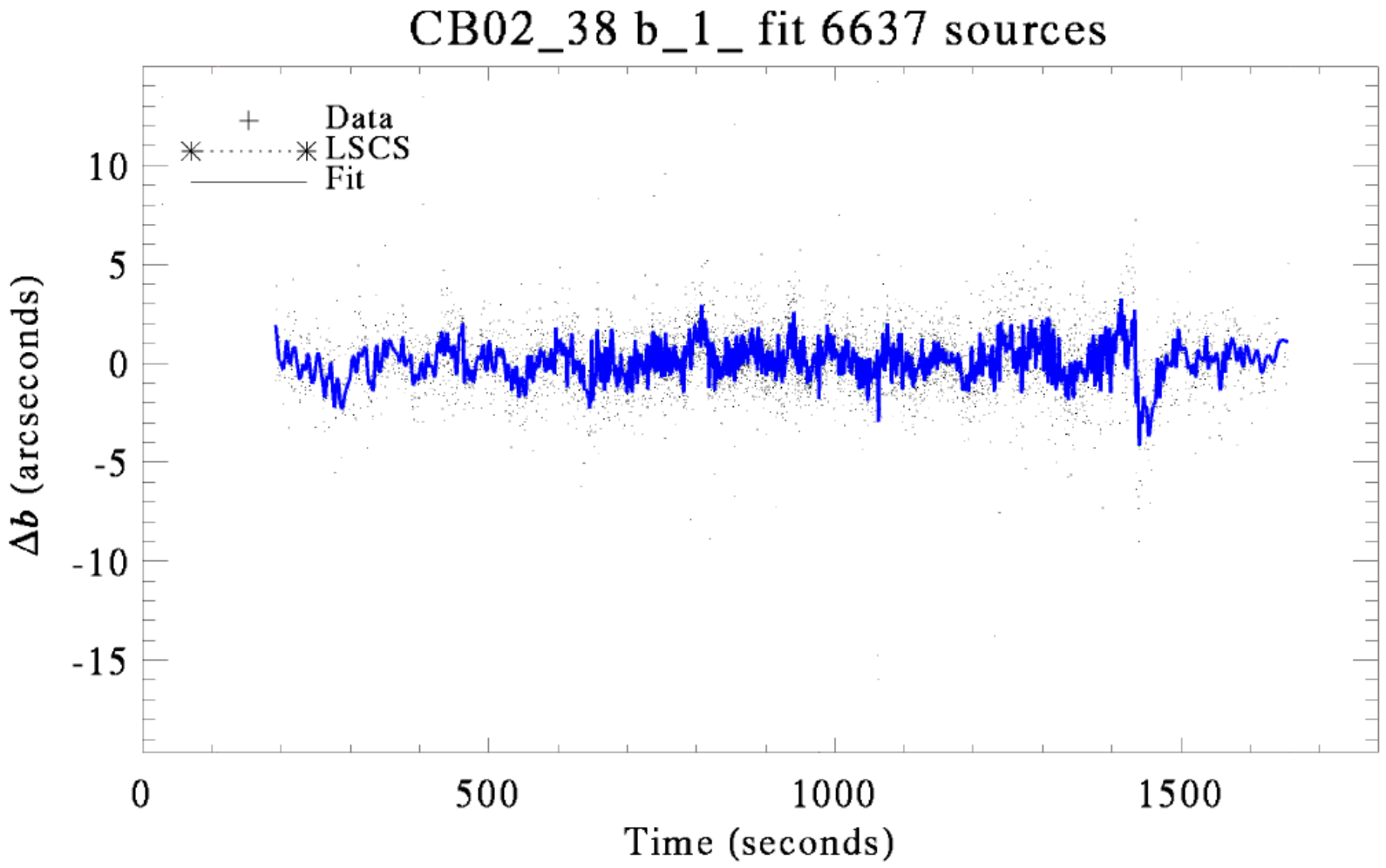
Astrometric Sources

- MSX Astrometric Catalog (0.12-0.2″ error)
  - ACRS
  - PPM
  - Fluxes: IRAS + models
- Need Additional Sources for Sparse Regions
  - Refined MSX Sources -or where available -
  - 2MASS Positions (< 0.2″ error) -and-
  - MSX Refined Fluxes

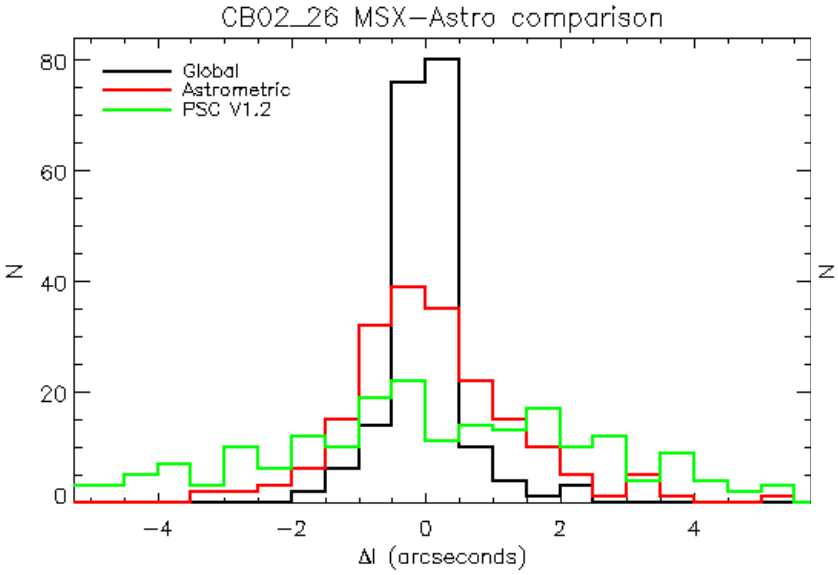
Fit to Astrometric Truth

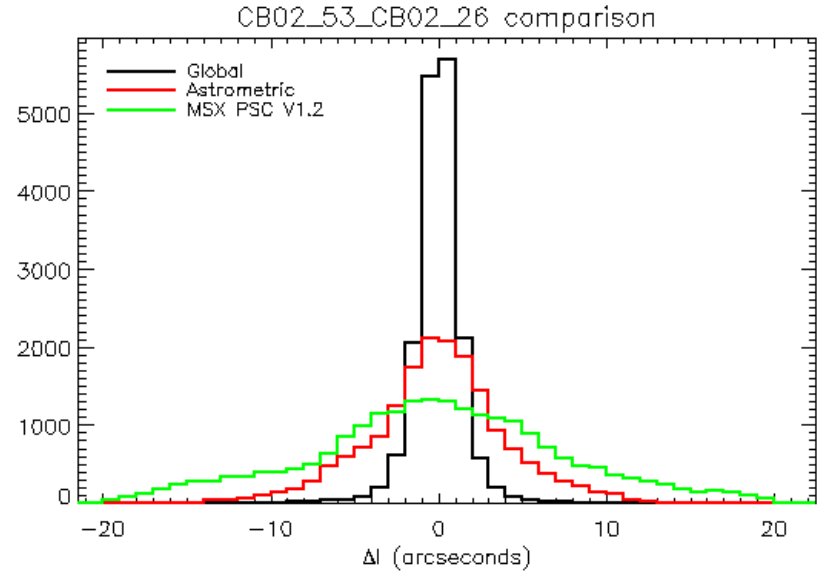


Global Registration



Pointing Improvement



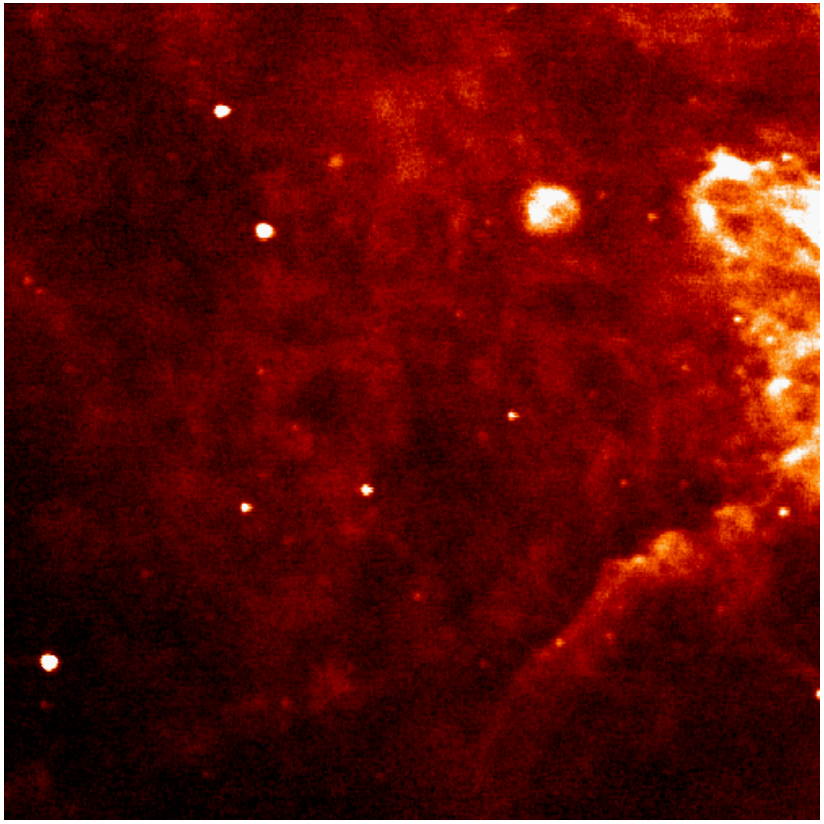


- MSX - Astrometric
- 30″ match window
- Global refinement
  - $\sigma(l) = 0.54''$
  - $\sigma(b) = 0.61''$

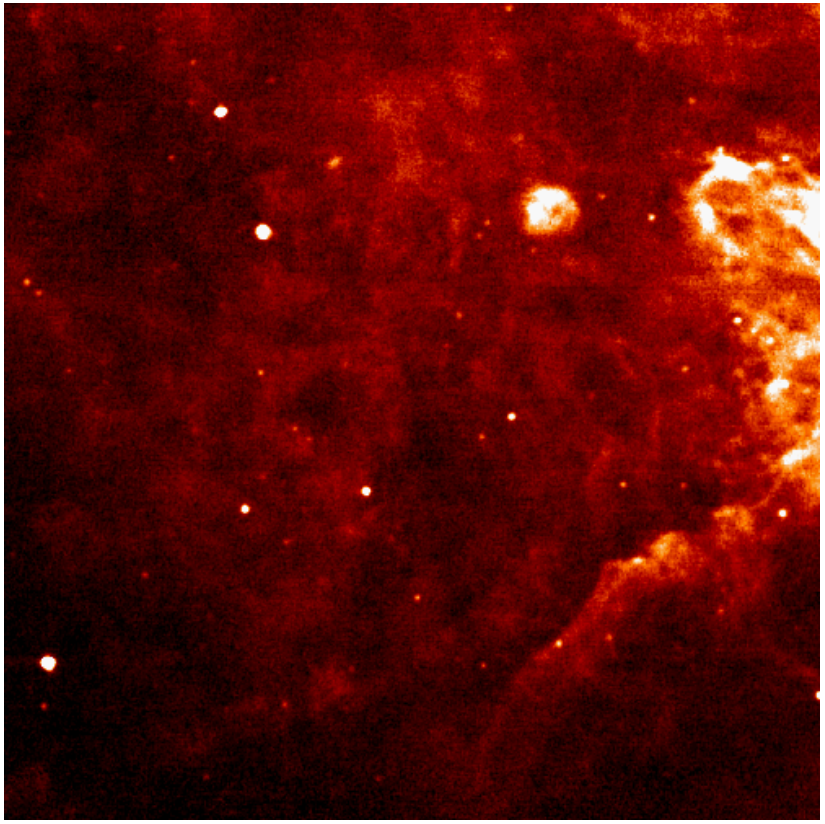
- MSX - MSX
- 30″ match window
- Global refinement
  - $\sigma(l) = 1.53''$
  - $\sigma(b) = 2.15''$

Pointing Improvement Registration of Images

Pre-refinement



Post-refinement



Pointing Improvement Summary

- MSX-Astrometric Match Uncertainty
  - In-scan $\sigma(l) = 0.8''$
  - Cross-scan $\sigma(b) = 1.0''$
- MSX-2MASS Uncertainty
  - Independent Measure
  - In-scan $\sigma(l) = 1.80''$
  - Cross-scan $\sigma(b) = 1.87''$

Summary

- Mission Requires < 1.8″ Positional Accuracy
- Boresight Positions Refined Through
  - Optimal Filtering
  - Comparison with Astrometric Truth
  - Global Registration (solution)
- Met Program Requirement
  - Imaging
  - Version 2 of MSX PSC

Description of DAF Errors

- Jumps
- Gaps
- Noise
- Attitude errors